

OVERVIEW OF ULTRA-EFFICIENT ENGINE TECHNOLOGY (UEET) PROGRAM

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UEET

Overview of ***Ultra-Efficient Engine Technology (UEET) Program***

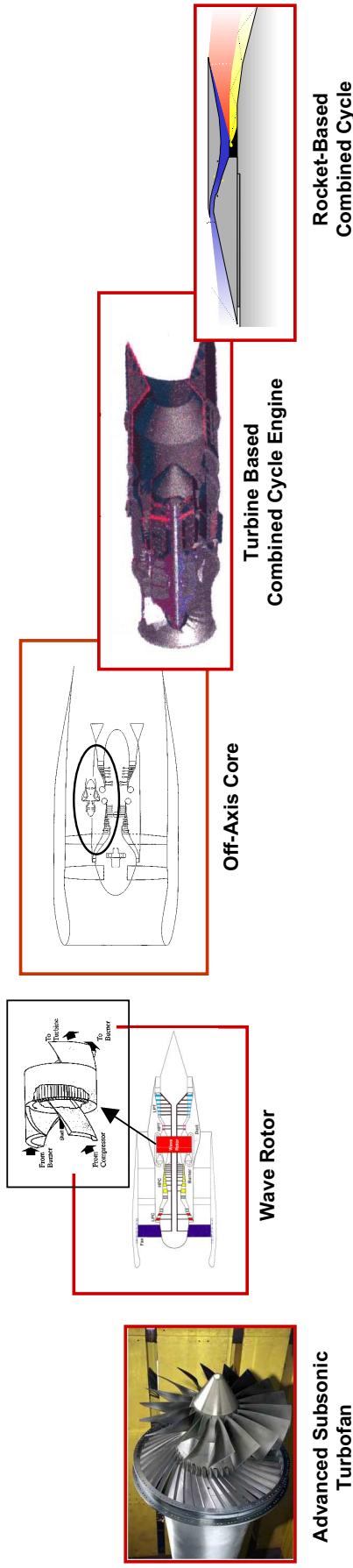
Joe Shaw
Chief, UEET Program Office
NASA Glenn Research Center
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Administrator's November 20, 1998 charge to NASA Glenn.....

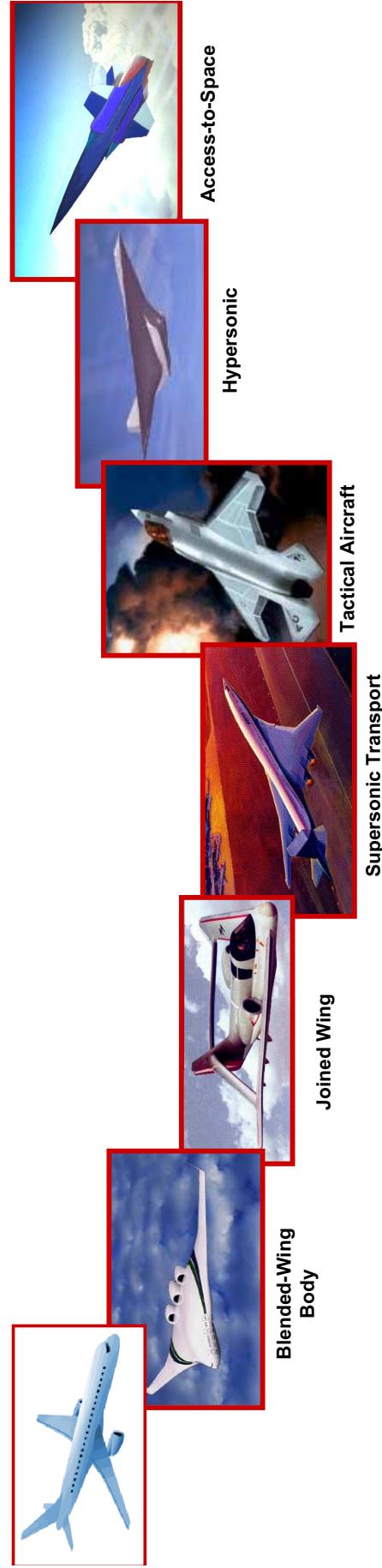
- Plan a 5 yr. engine technology program that will enable next generation engines for both commercial and military applications.**
- Emphasize revolutionary technologies that will enable future subsonic and high-speed applications. Actively seek collaboration with the DOD.**

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Vision Statement (*Draft*)



Develop and transfer revolutionary propulsion technologies that will enable future generation vehicles over a wide range of flight speeds.



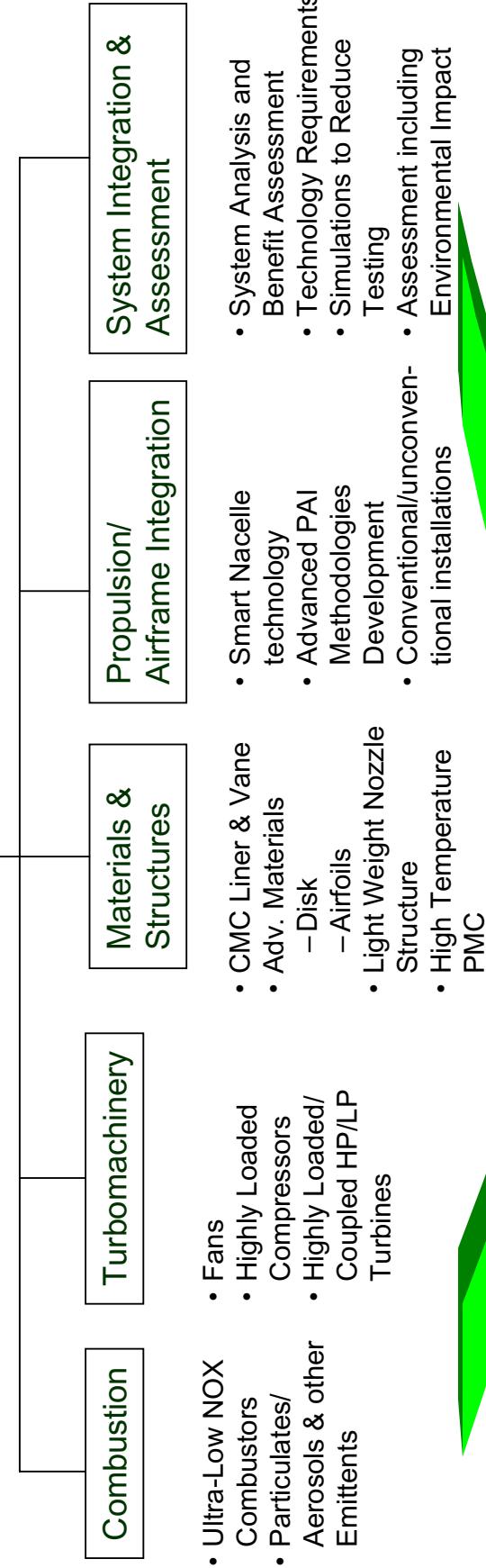
Develop and transfer revolutionary propulsion technologies that will enable future generation vehicles over a wide range of flight speeds.

- Address long term aviation growth potential without impact on climate by providing technology for dramatic increases in efficiency to enable reductions in CO₂ based on an overall fuel savings goal of up to 15%.
- Address local air quality concerns as well as addressing potential ozone depletion by developing technology for 70% NOx emissions reduction at take-off and landing conditions, and also technology to enable aircraft to not impact the ozone layer during cruise operation.
- Technology Readiness to the Component Level (TRL 4-5).

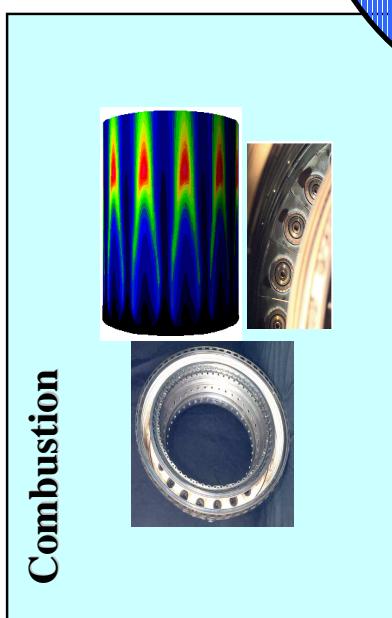
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Investment Areas

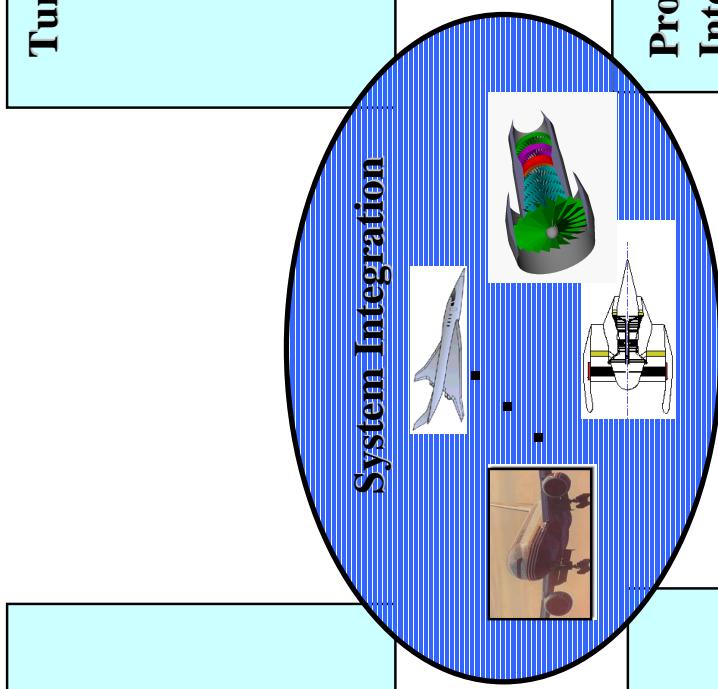
Ultra-Efficient Engine Technology



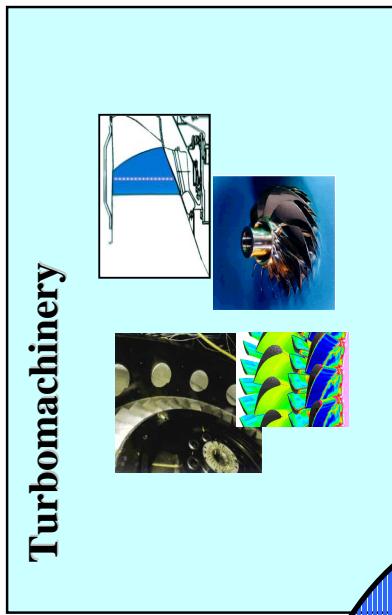
A Portfolio of Enabling Technologies for Future Generations of High Performance Engines (Commercial and Military)



Combustion

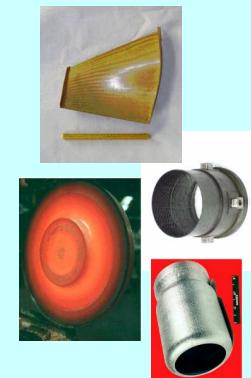


Turbomachinery

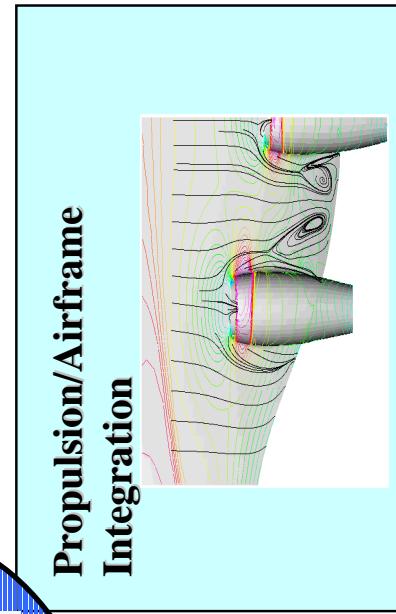


Turbomachinery

Materials and Structures

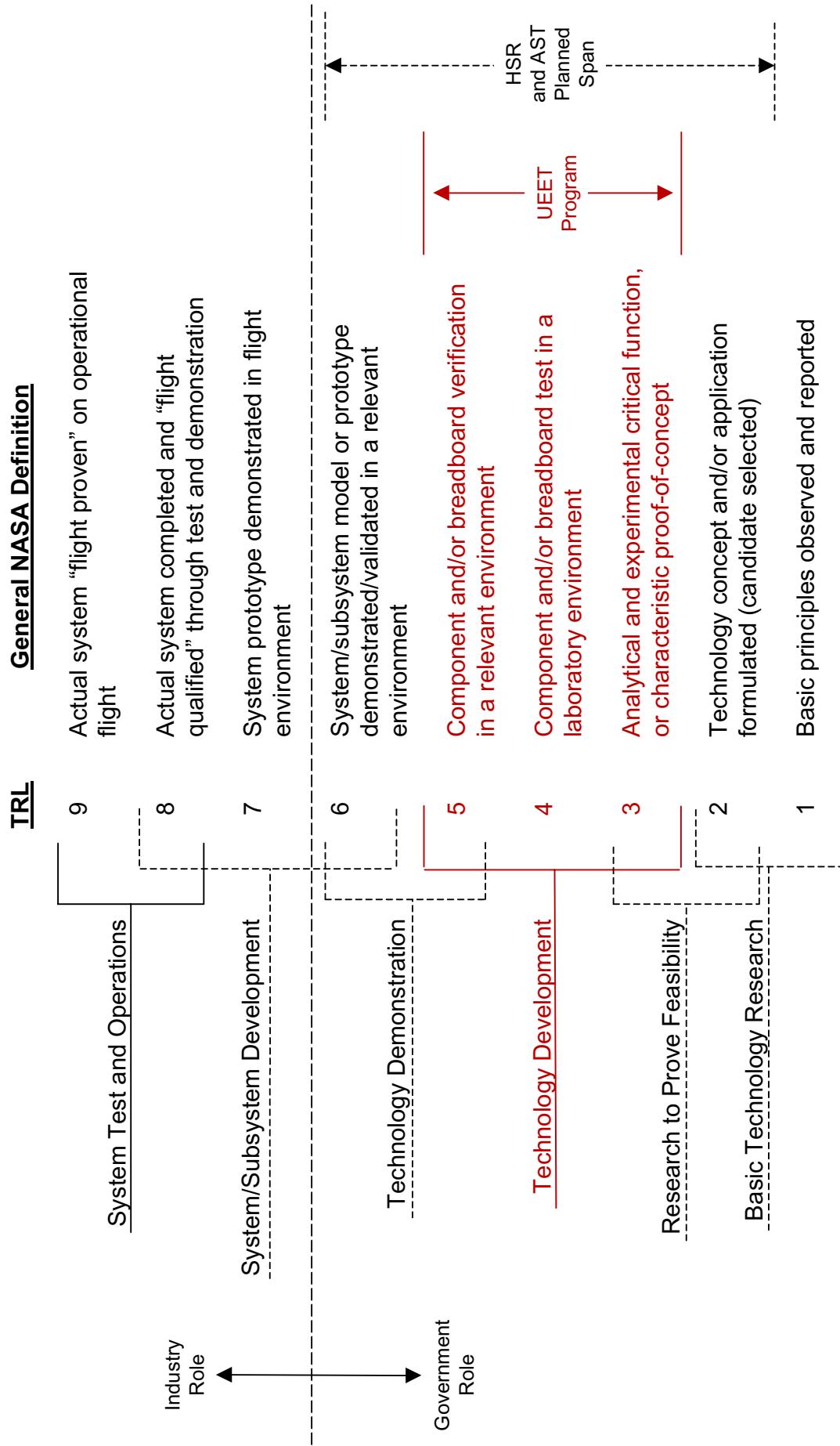


Propulsion/Airframe Integration



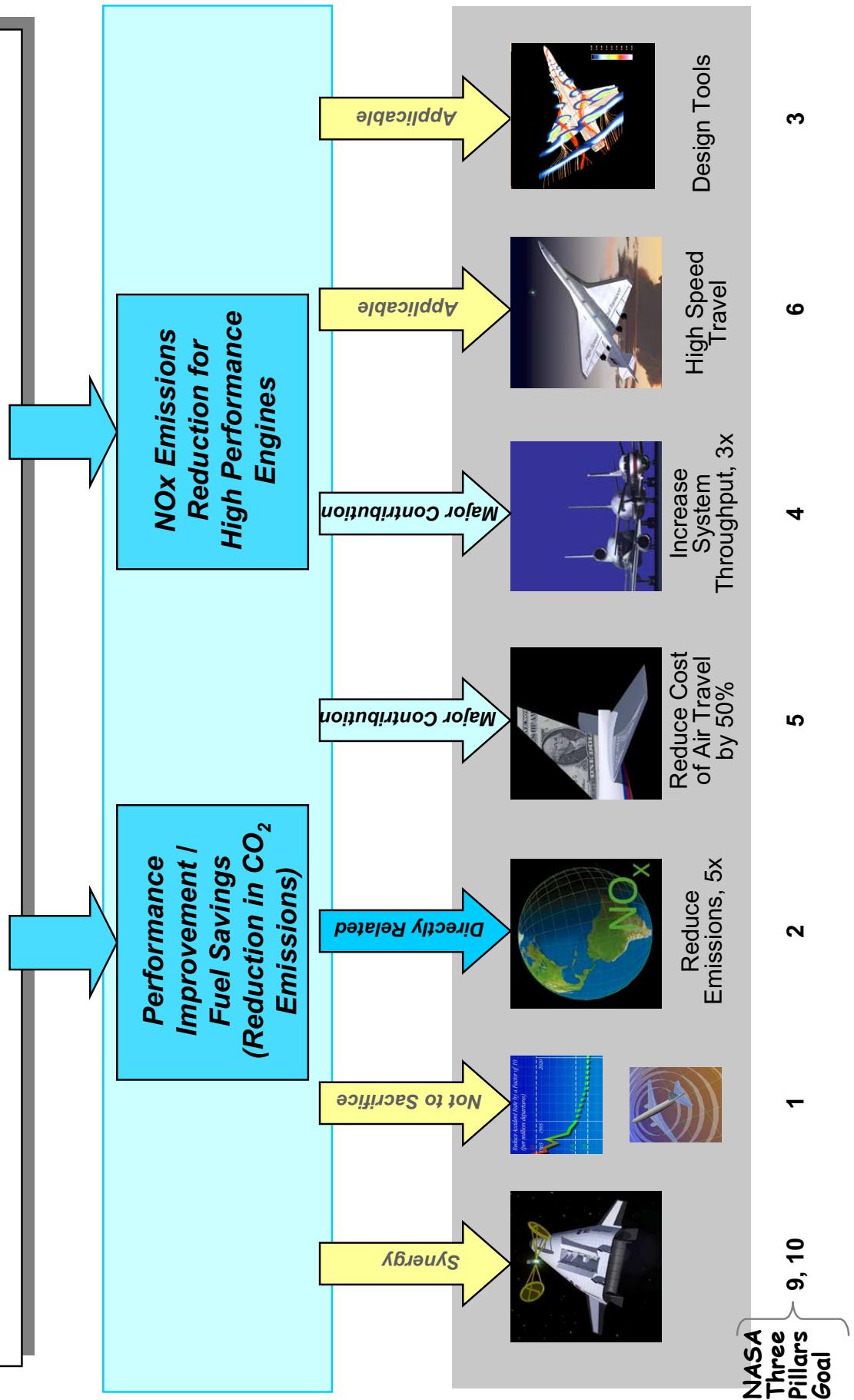
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NASA's Technology Readiness Level (TRL) Scale Applied to UEET Program



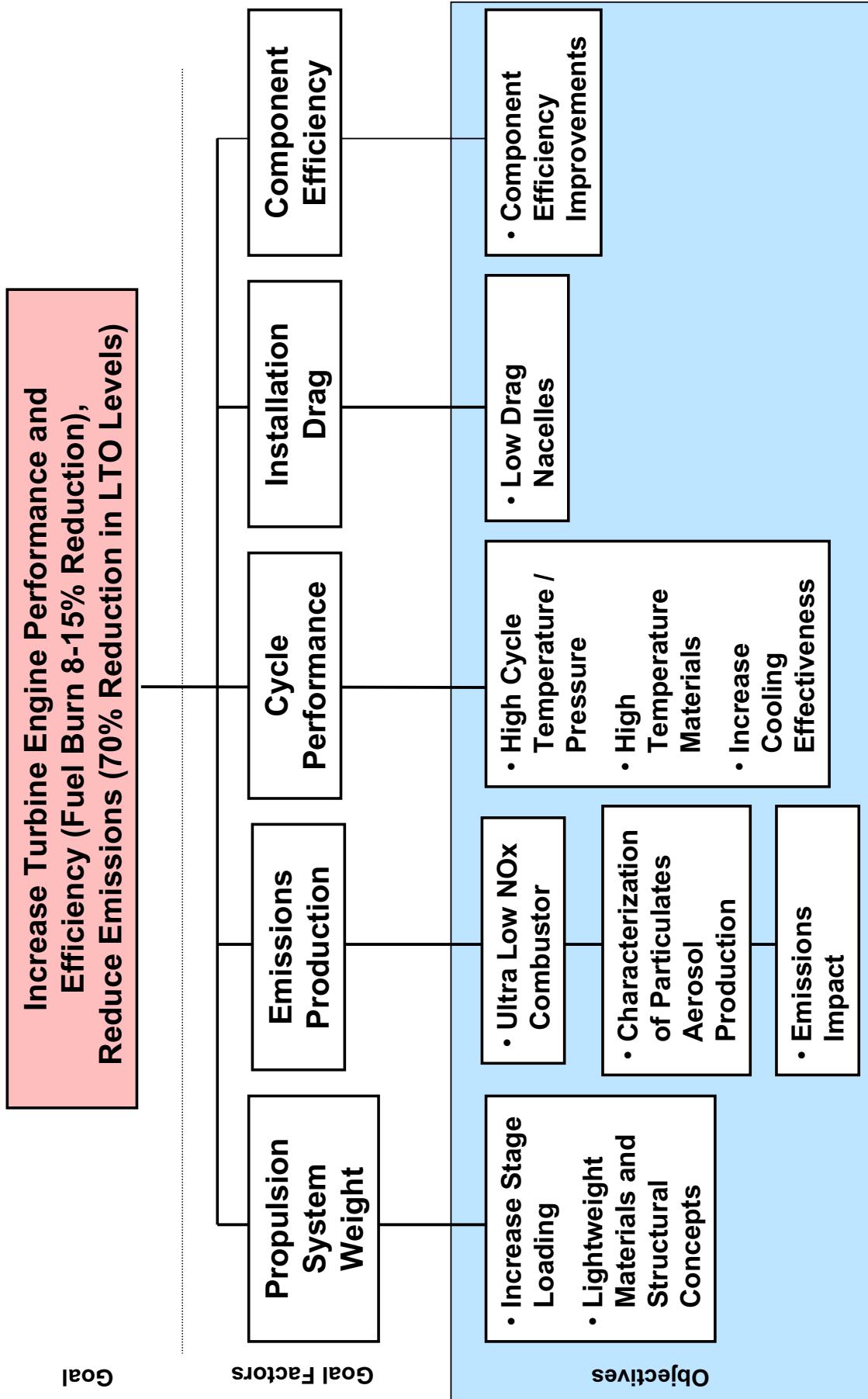
Ultra-Efficient Engine Technology Program

Increased engine performance to enable and enhance a wide range of revolutionary aircraft from small to large, and over a wide range of flight speeds



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Overview



- 1.0 Systems Assessment**
- 2.0 Emissions Reduction**
- 3.0 Highly Loaded Turbomachinery**
- 4.0 Materials and Structures for High Performance**
- 5.0 Propulsion Airframe Integration**
- 6.0 Program Management**

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Level I Milestone Schedule

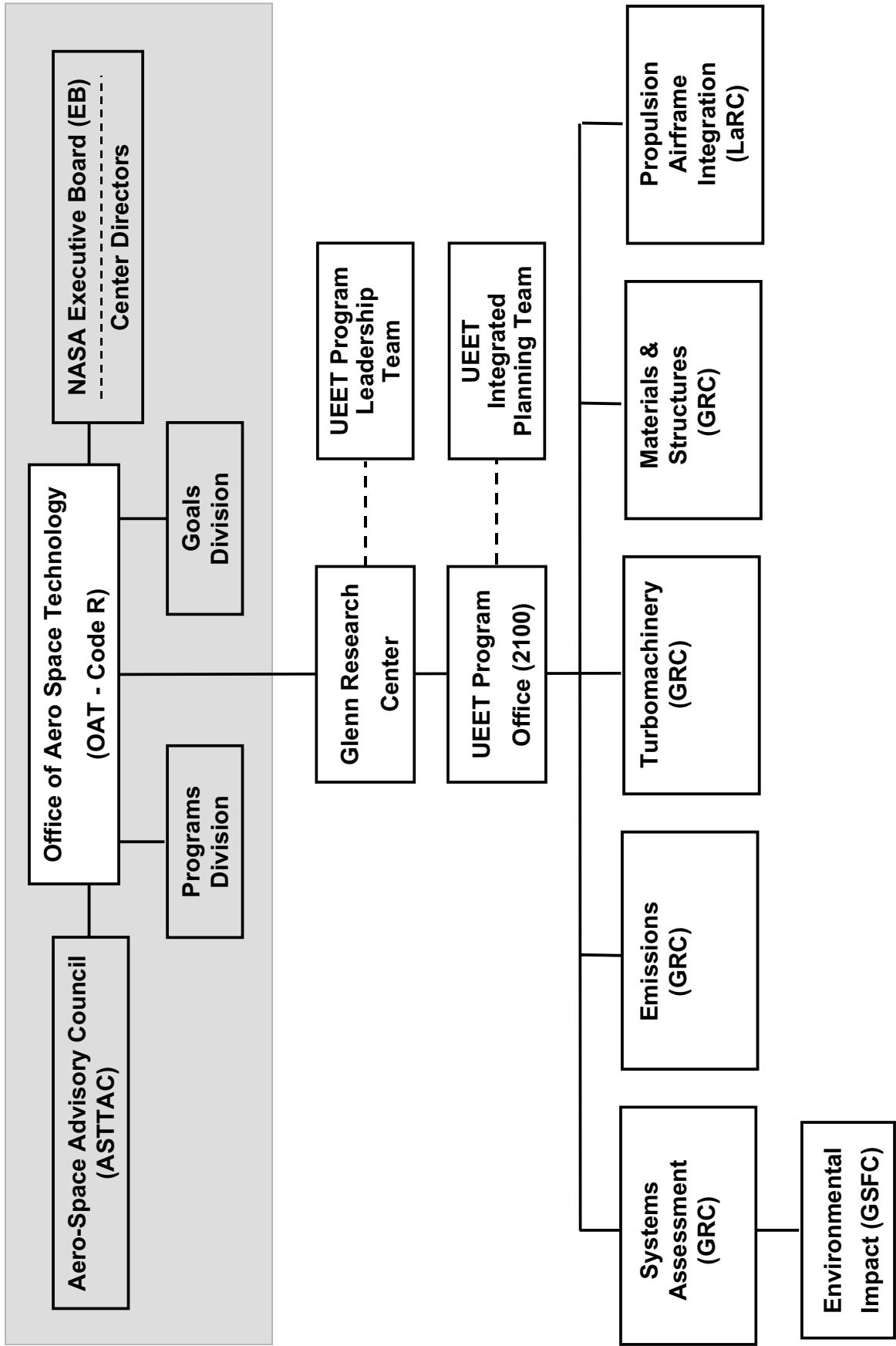
	FY	2000	2001	2002	2003	2004
1.0 Systems Assessment		Preliminary Technology Benefits Assessment	Propulsion System(s) Conceptual Definition	Interim Technology Assessments	Initial High Fidelity System Simulation	Final Technology Assessment
2.0 Emissions Reduction		Flametube Eval's. of 70% LTO NOx Concepts	Sector Eval's. of 70% LTO NOx Configurations	Sector Demo (Cruise NOx)	Init. Annular Rig Demos (Lg. Eng.) - 70% LTO NOx Configs.	CMC Annular Rig Demo - 70% LTO NOx
3.0 Highly Loaded Turbomachinery		Flow Control Concept(s) Selected - Turbine	Flow Control POC		Physics Based Prediction Codes Validated (T/M)	Physics Based Prediction Codes Validated
Fan					Flow Control Validation	
Compressor					Highly Loaded Multistage Validation	
Turbine					Highly Loaded HP/LP Validation	
4.0 Materials & Structures for High Performance		Ceramic Thermal Barrier Coating Concept(s) Selection	Mat'l Sys. for CMC Turbine Vane	CMC Complex Part Demo	High Temperature Materials Capabilities Demos.	Final High Re Validation of Method
		1350°F Turbomachinery Disk Alloy	Ceramic Thermal Barrier Coating / Process Structure	Eng. Demo of PMCs	1400°F Disk Process	Eval. of Active Flow Control Approaches
5.0 Propulsion Airframe Integration		Methods Downselect	Eval. of Active Flow Control Concepts	Init. High Re Validation of Method		

Notes: 1) All level I milestones are GPRAs.

2) PCA milestones are denoted by 

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Program Organization Structure

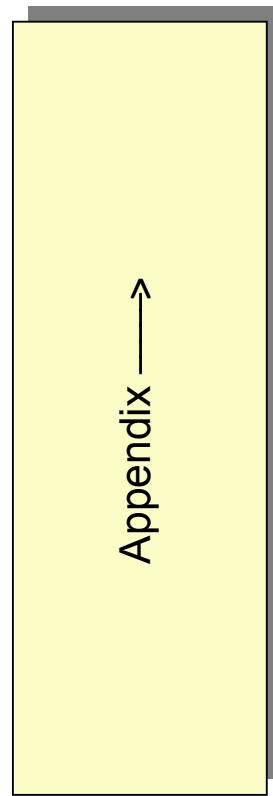


<u>Name</u>	<u>Organization</u>
Joe Shaw	NASA Glenn
Steve Jones	P&W
Fred Krause	GE
Vinod Nangia	Allied Signal
Scott Cruzen	Williams International
Gerry Brines	Allison
Jeff Lewis	Boeing
Don Williams	Lockheed-Martin

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Program Management Team

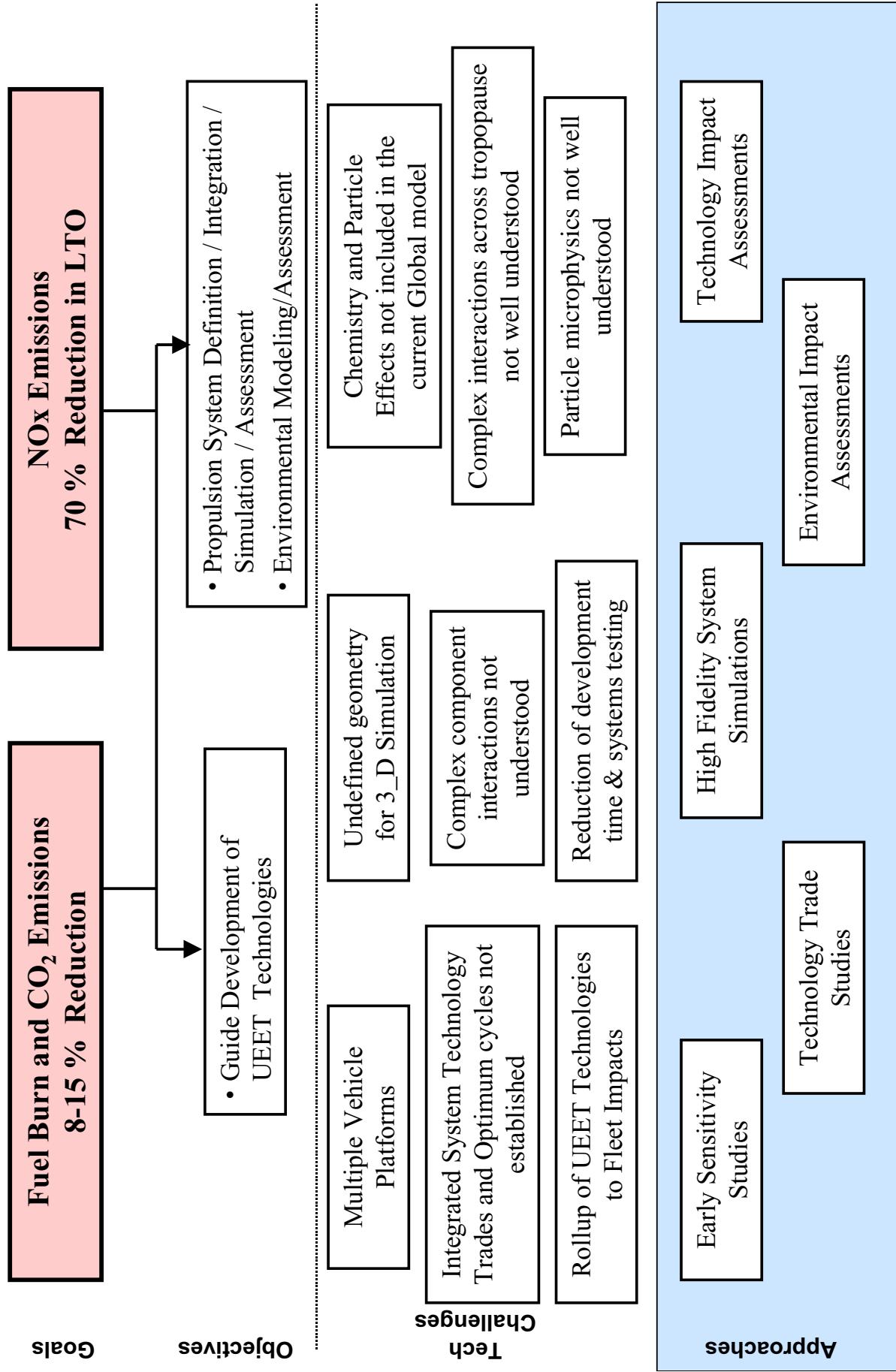
<u>Name</u>	<u>Organization</u>	<u>Responsibility</u>
Joe Shaw	UEET Program Office	Program Manager
Bob Plenner	High-Speed Systems Office	Systems Assessment Project Manager (1.0)
John Rohde	Subsonic Systems Office	Emissions Project Manager (2.0)
Kaz Civinskas	Subsonic Systems Office	Turbomachinery Project Manager (3.0)
Ajay Misra	High-Speed Systems Office	Materials and Structures Project Manager (4.0)
Jim Pittman	Aero Performing Center Management Office	Propulsion Airframe Project Manager (5.0)



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Overview

Systems Integration & Assessment (1.0)

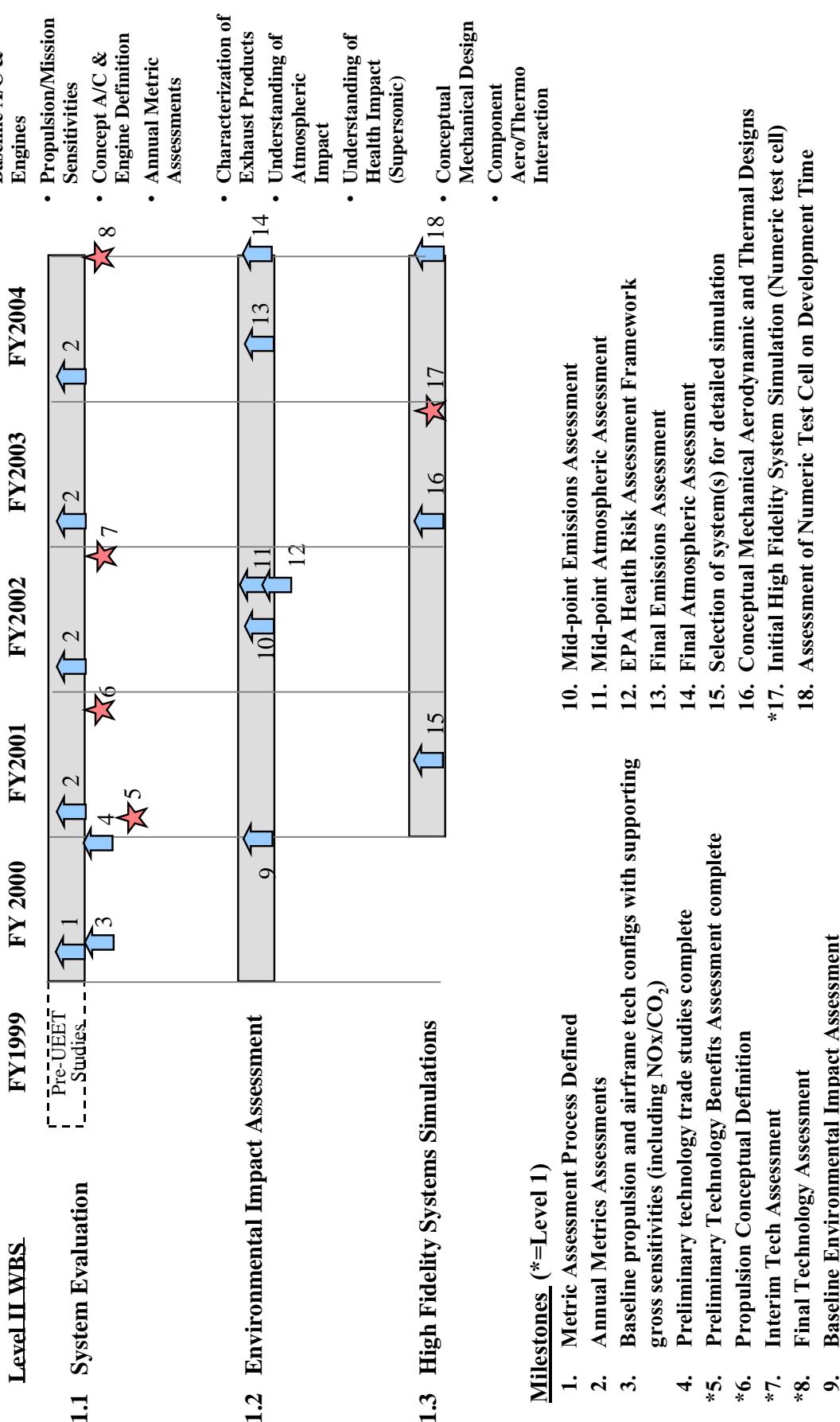


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Level I and II Milestone Schedule

Systems Integration & Assessment (1.0)

Level II WBS



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Overview Supersonic

Emissions Reduction (2.0)

Fuel Burn and CO₂ Emissions
8-15 % Reduction

NOx Emissions
70 % Reduction in LTO

Objectives

NOx < 4 EI, Efficiency > 99.9%
at Supersonic Cruise and Comparable LTO NOx Reduction

Challenges

Reduced Liner
Cooling Air

Low NOx
Scale-up
Operability

High Temperature

Approaches

Adv Liner Mat'l / Design

Lean Burn

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Tech

Approaches

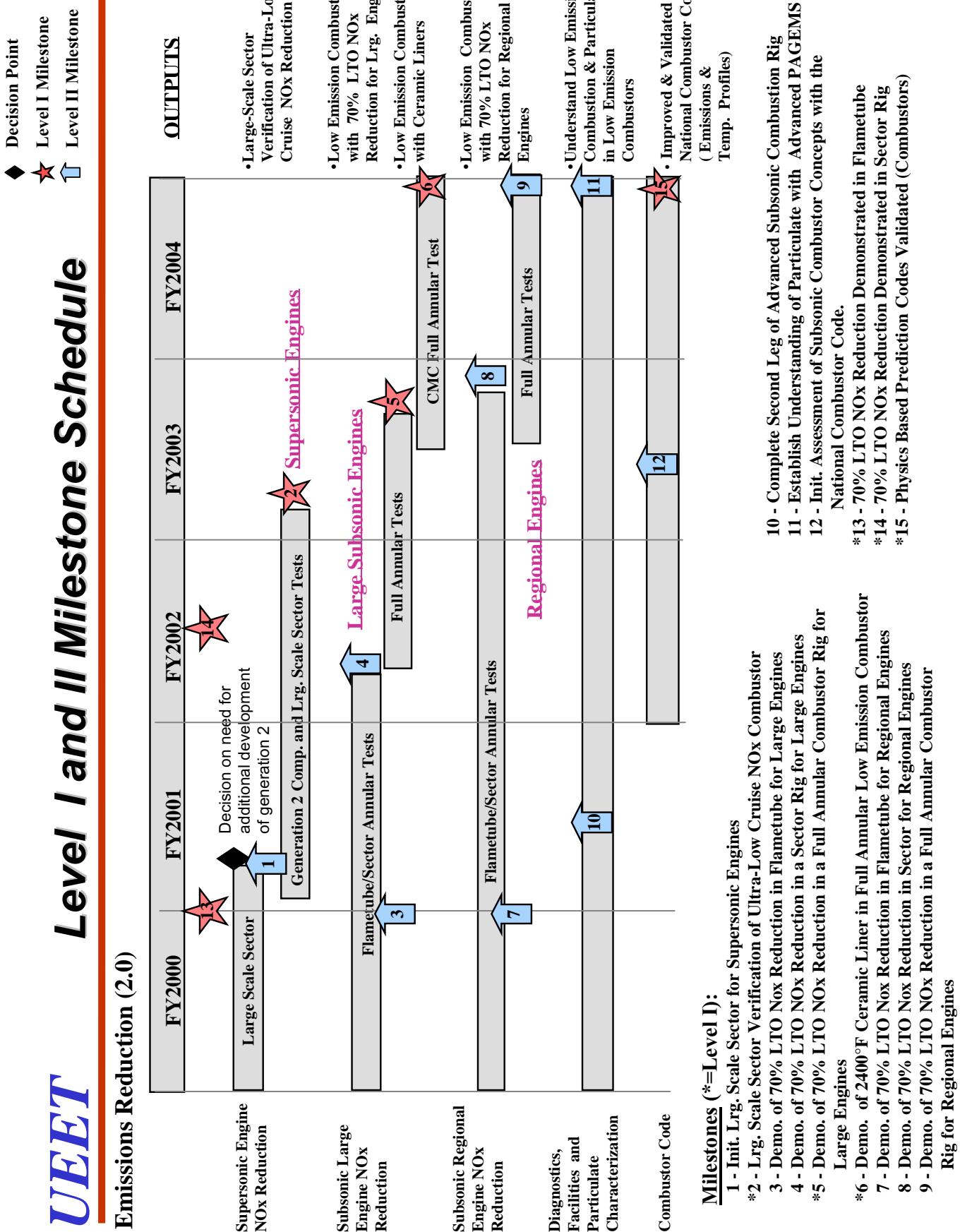
Lean Burn

Adv Liner Mat'l / Design

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Level I and II Milestone Schedule

Emissions Reduction (2.0)



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Overview

Highly-Loaded Turbomachinery (3.0)

Fuel Burn and CO₂ Emissions
8-15 % Reduction

NOx Emissions
70 % Reduction in LTO

Reduce Component Weight -20%, Engine Weight -5%

Increase Average Stage Loading +50%

Increase Efficiency by 1% to 2%

Reduce Cooling Flow by 25%

Increase Turbine Inlet Temperature +400°F at Commercial Life

Goals

Objectives

Tech Challenges

- Large fan stage rotor-stator spacing dictated by noise
- High risk for structural integrity of blades
- Flow through blades limited by thickness
- Aero design needs to satisfy all operating conditions
- Minimize cost/complexity of new technology
- Minimize fan/stator interaction noise with reduced spacing
- Execute flow control concepts in 3D design

• Strong interaction of shock and viscous layers

- Increased diffusion in blade rows leads to higher losses without flow control
- Goals require turbomachinery performance beyond current “design space”
- Current design rules lead to low aspect ratios which will tend to increase weight & losses
- Higher aspect ratio at high loading levels susceptible to aeromechanical problems
- Higher loading limited by flow breakdown near endwalls and on blading
- Stability impacted by strong interaction between leakage flows and shocks

OPR

- Higher coolant temperature at 55:1
- Accurate prediction of internal and external heat loads
- Prediction of localized heat transfer effects particularly at edges & tips
- Unsteady effects on film-cooling effectiveness
- High Mach effects between HP and LP turbine stages (shock & mixing losses)
- Adverse flow impact of high-flare interstage duct & LP geometries

Approaches

- Trailing edge blowing to fill wakes and allow close coupling
- Flow management through self-pumping within blade (Aspirated airfoils)
- Endwall and tip leakage flow management
- 3D viscous inverse design

• Physics-based modeling of flow control concepts

- 3D blading (sweep, lean, scallop, etc)
- Multistage 3D viscous CFD (steady & unsteady)
- Active/pассиве stability control
- Rig tests of flow control concepts in single-stage, multistage, and subsystem configurations

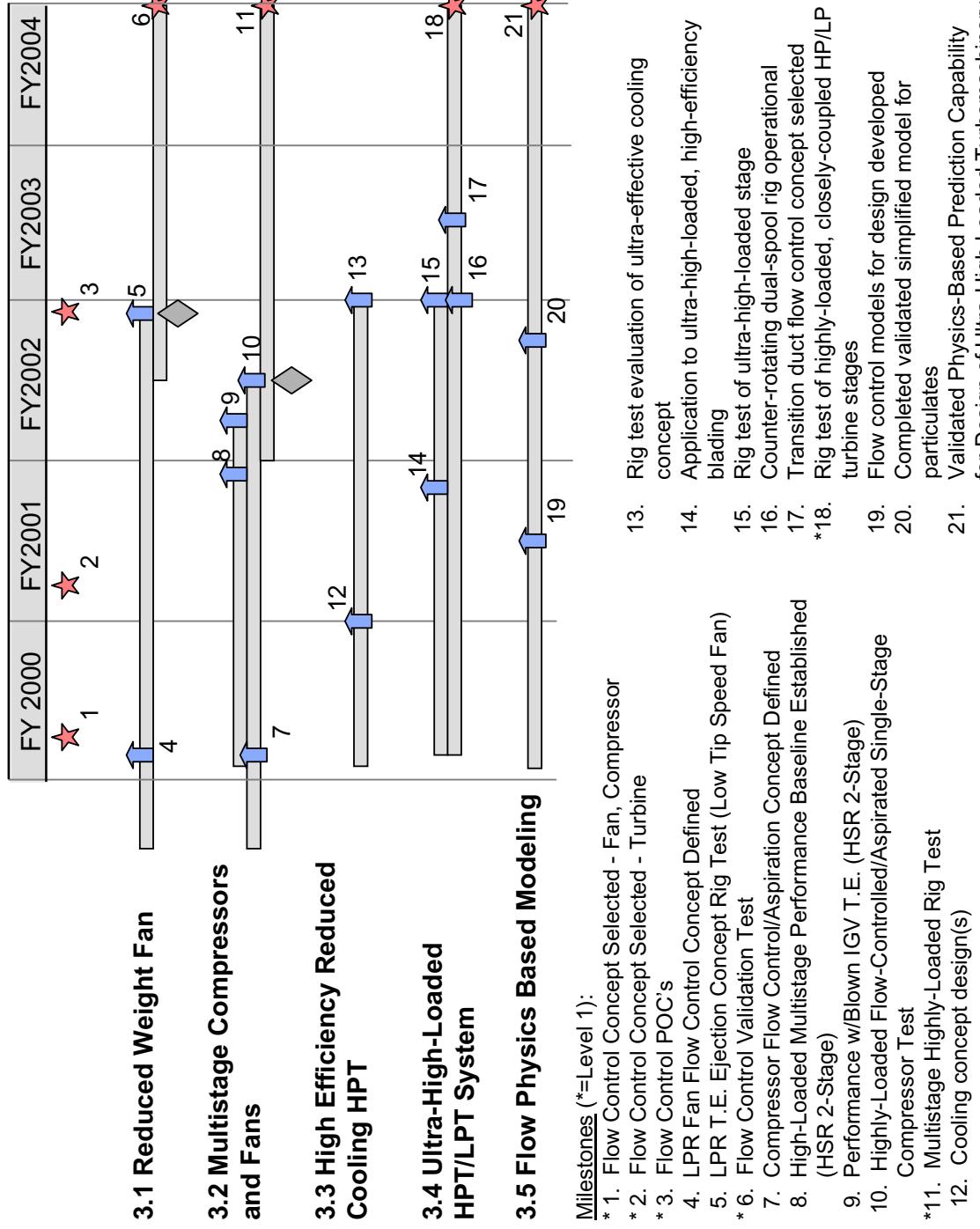
• Physics-based fluid/structural modeling for 3D heat transfer analysis of advanced cooling

- Aspirated LP airfoils
- Flow control for HP/LP turbine interstage ducting
- Rig test of close coupled HP/LP turbine system in dual-spool facility

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Level II Milestone Schedule

Highly-Loaded Turbomachinery (3.0)



OUTPUTS

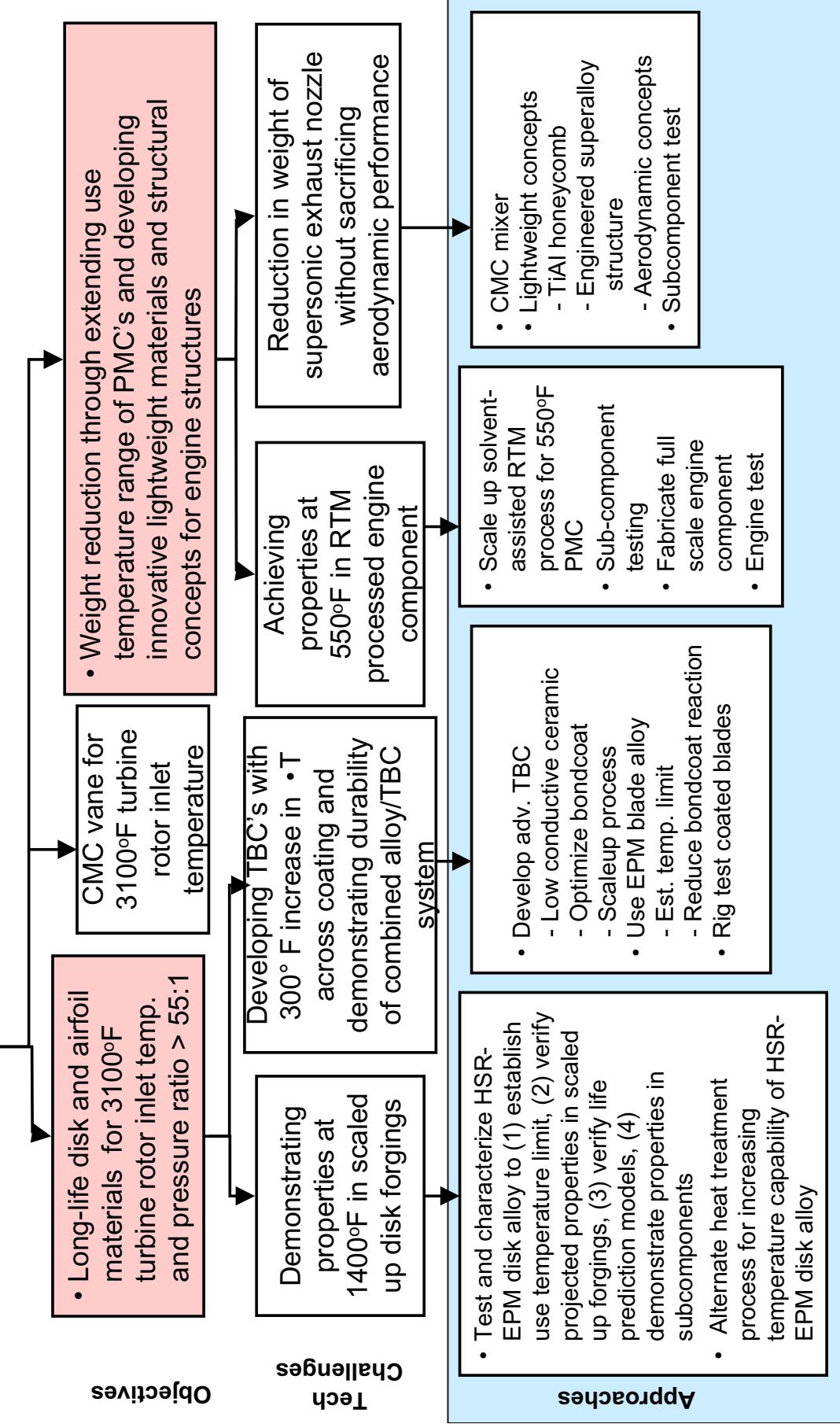
- Baseline Performance Database
- Blown IGV Performance
- R-S Close Coupling
- Demonstration of Flow Control/Aspiration Concepts in Single-Stages
- Ultra-effective cooling concept
- 55 OPR, 3100Fw/25% less coolant
- Demo. Of Flow Control Concept for LPT
- Multistage/Subsystem Demo. of Ultra-High Aero Loading
- Demo. of Ultra-High Loaded HPT/LPT Subsystem
- 1/3 fewer stages
- Physics-Based Prediction Codes

Overview (1 of 2)

Materials & Structures for High Performance (4.0)

Fuel Burn and CO₂ Emissions 8-15 % Reduction

NOx Emissions 70 % Reduction in LTO

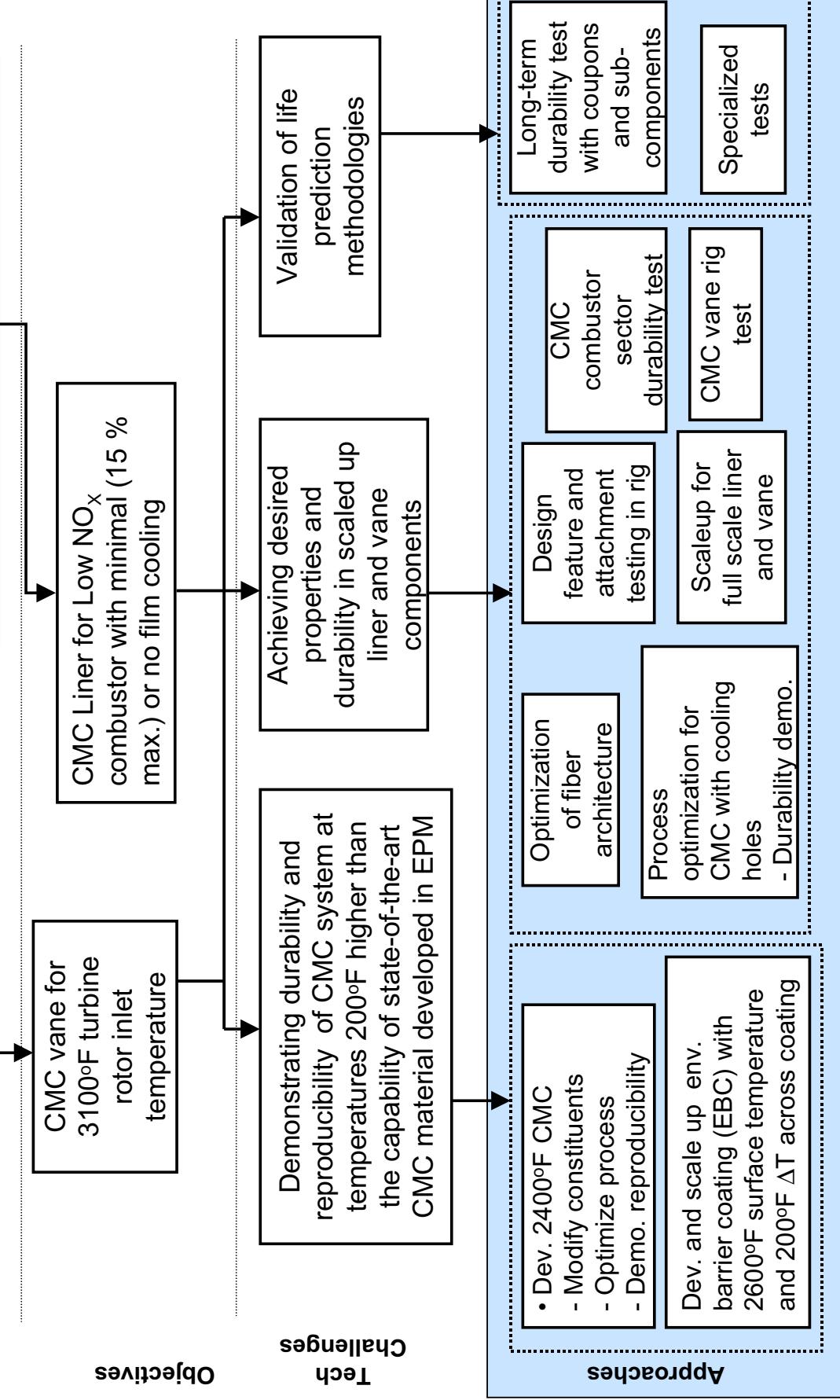


Overview (2 of 2)

Materials & Structures for High Performance (4.0)

**Fuel Burn and CO₂ Emissions
8-15 % Reduction**

**NOx Emissions
70 % Reduction in LTO**

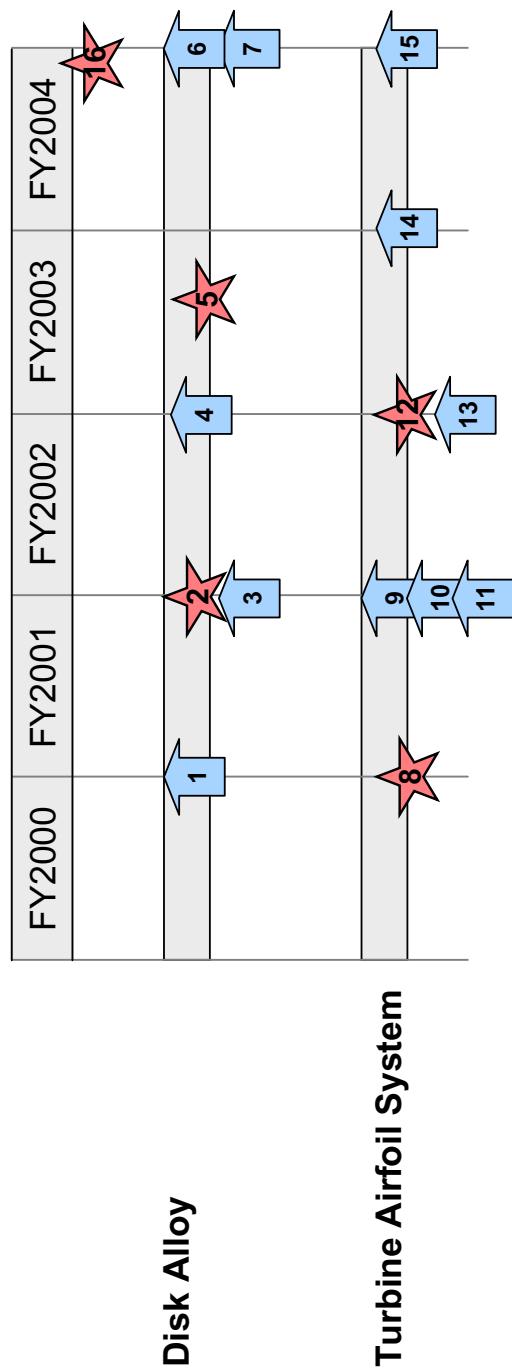


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Materials & Structures for High Performance (4.0)

Level II Milestone Schedule

- ◆ Decision Point
- ★ Level I Milestone
- ↑ Level II Milestone

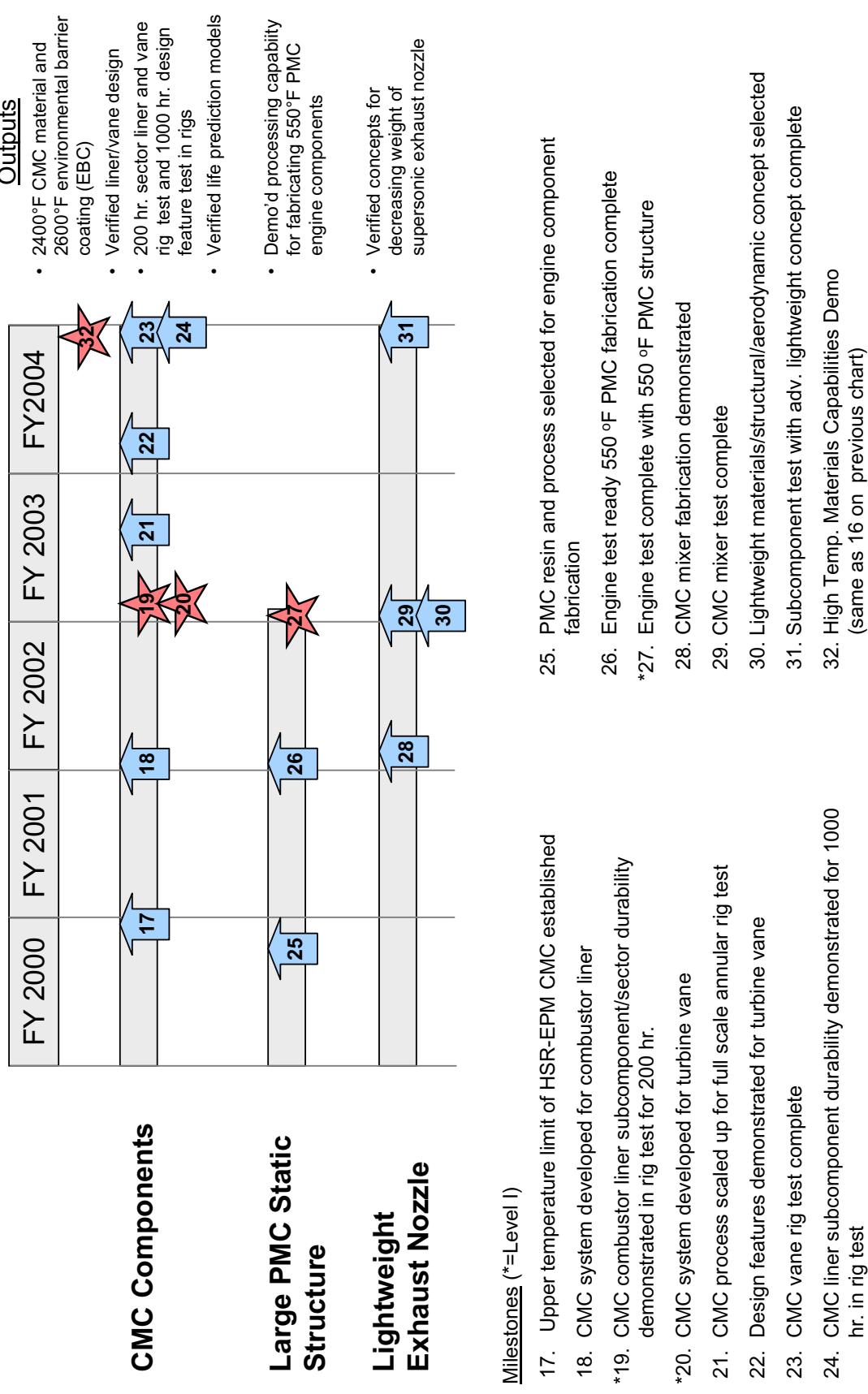


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Level II Milestone Schedule

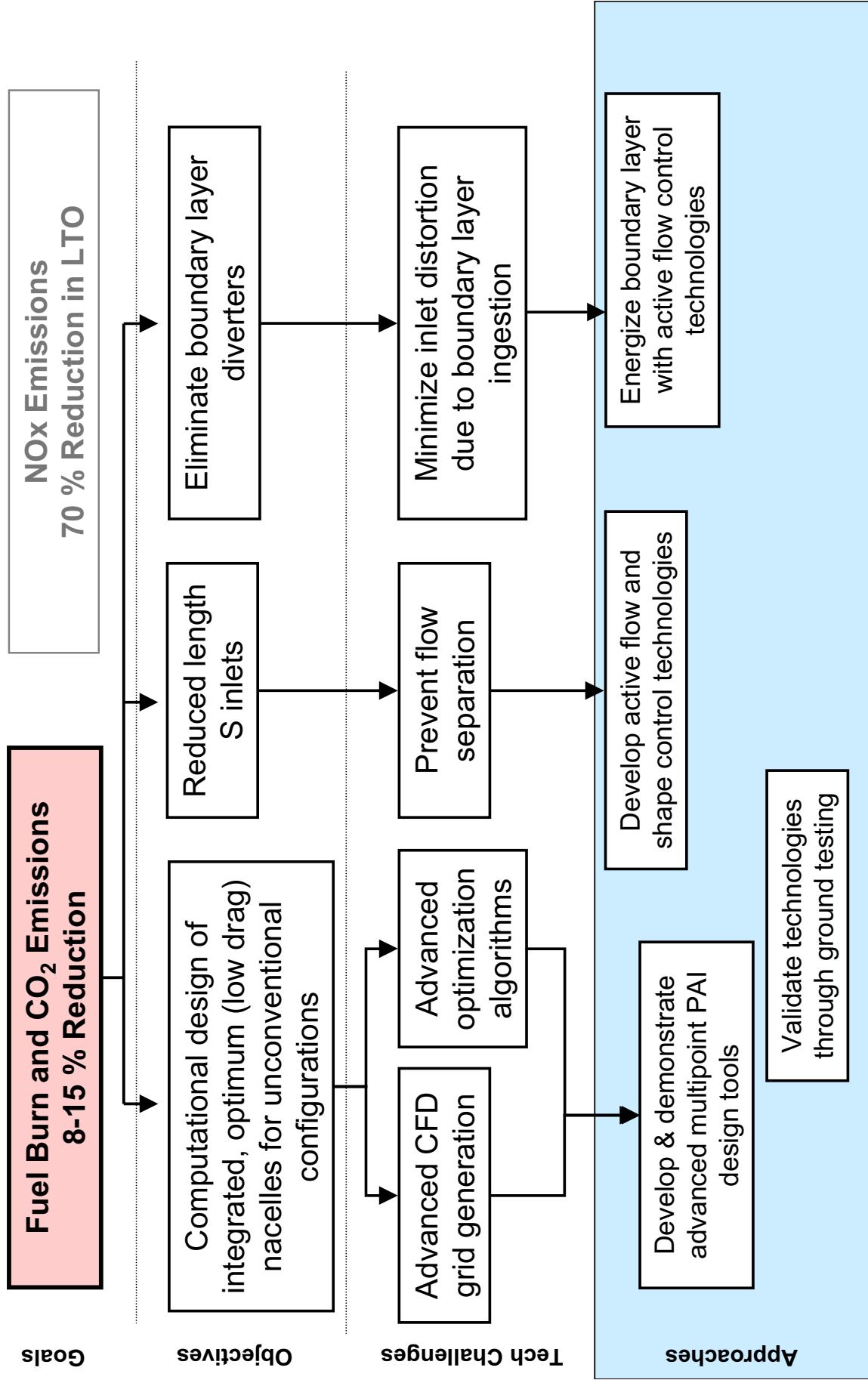
Materials & Structures for High Performance (4.0)

- ◆ Decision Point
- ★ Level I Milestone
- ↑ Level II Milestone



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Overview



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Level 2 Milestone Schedule

- ◆ Decision Point
- ★ Level I Milestone
- ↑ Level II Milestone

